12.8 PREDATION IN AN ANTARCTIC MICRO-ARTHROPOD COMMUNITY

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INTRODUCTION

Polyacrylamide gel electrophoresis has been used to demonstrate the diets of arthropod predators in the laboratory and to a limited extent in the field (Murray & Solomon 1978, Giller 1982), but no extensive field application has been reported.

The Antarctic predatory mesostigmatid mite, *Gamasellus racovitzai* (Trouessart), is an ideal subject. It is the sole predator in the terrestrial micro-arthropod community of Signy Island, South Orkney Islands (60°43′S, 45°38′W) and it has been observed to feed upon only eight prey species (Table 1). In this study the three largest and most abundant prey – *Cryptopygus antarcticus* Willem, *Parisotoma octooculata* (Willem), and *Alaskozetes antarcticus* (Michael) – were identified by their characteristic esterase band patterns. The pattern of predation over a twelve-month period is examined, and comparisons between apparent diet and prey abundance are made.

Table 1

Observed prey species of *Gamasellus racovitzai* in approximate order of significance.
Sources: G, Goddard (1982); L, personal observation; S, Strong (1967)

Species	Sources
COLLEMBOLA	
Cryptopygus antarcticus Willem	G,L,S
Parisotoma octooculata (Willem)	L
CRYPTOSTIGMATA	
Alaskozetes antarcticus (Michael)	G,L
PROSTIGMATA	
Stereotydeus villosus (Trouessart)	G,L
Eupodes minutus (Strandtmann)	G
Ereynetes macquariensis Fain	G
Tydeus tilbrooki Strandtmann	G
Nanorchestes antarcticus Strandtmann	L

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MATERIALS AND METHODS

Specimens of *G. racovitzai* were collected directly in the field or extracted from soil cores in the laboratory. Sample sites ranged from low nutrient status moss turf and fellfield sites to loose undifferentiated soils beneath cliffs with a high nutrient input from seabird guano. Animals were extracted from soil cores by teasing out the cores on wire meshes in collecting trays. Precautions were taken to prevent feeding under any other than field conditions. The mites were killed and preserved by being frozen to between −20°C and −40°C as soon as possible after collection. This also facilitated sorting and preparation for electrophoresis. A few specimens were stored deep-frozen for six or seven months before electropohoresis without any apparent deterioration.

Individual mites were macerated in a slight excess of buffer. The maceration buffer used was identical to that of Murray & Solomon (1978) except for the addition of the purified protein markers, bovine serum albumin (0.01% w/v) and thyroglobulin (0.05% w/v). Pre-cut lengths of polythene capillary tubing were used to draw up a known volume of macerate. Initially 1-μl capillary tubes were used, but this was later increased to 10 μl to reduce the proportion of each sample wasted. Perspex holders allowed twenty samples to be applied simultaneously to each gel (nominally 75x75x3 mm).

Gradient gels manufactured on Signy Island, following the methods of Margolis & Wrigley (1975) and Murray (pers. comm.), were found to produce better separation of critical bands than commercially available gels.

After electrophoresis, typically 10 h at 100 V, the gels were immediately stained to reveal bands of esterase activity (Murray & Solomon 1978), then fixed and cleared of background stain for a minimum of 8 h in acetic acid (7% v/v). The reference bands of albumin and thyroglobulin were visualized by staining in amido black (0.2% w/v in acetic acid 7% v/v) for 1–2 h before final destaining by transverse electrophoresis. Stained gels have been stored in acetic acid 7% for up to 18 months without deterioration.

The completed gels have both blue reference bands and brown-magenta esterase bands. The inclusion of marker bands in every sample provides a check against aberrant tracks, and allows comparisons to be made between gels without the need for separate prey reference traces on each gel, even where gels or electrophoretic conditions vary slightly.

Esterase bands were quantified by transmission densitometry with light of wavelength 510 nm, selected for maximal absorption, on an RFT Transidyne 2995 scanning densitometer.

RESULTS

Fig. 1 shows the different characteristic esterase bands of *G. racovitzai, C. antarcticus, P. octo-oculata*, and *A. antarcticus*, and demonstrates the use of the reference protein bands to diagnose invalid tracks. There is evidence of feeding upon all three prey species by the predator, in various combinations.

Fig. 2 presents a summary of all the electrophoresis samples. A broad separation can be made between the high nutrient and the low nutrient sites. The results are in chronological order within each division. The numbers of *G. racovitzai* with traces of each prey species and without any traces are expressed as percentages of the total sample in each case. Thus, where some predators show traces of more than one species of prey, the total of all four groups will exceed 100 per cent.

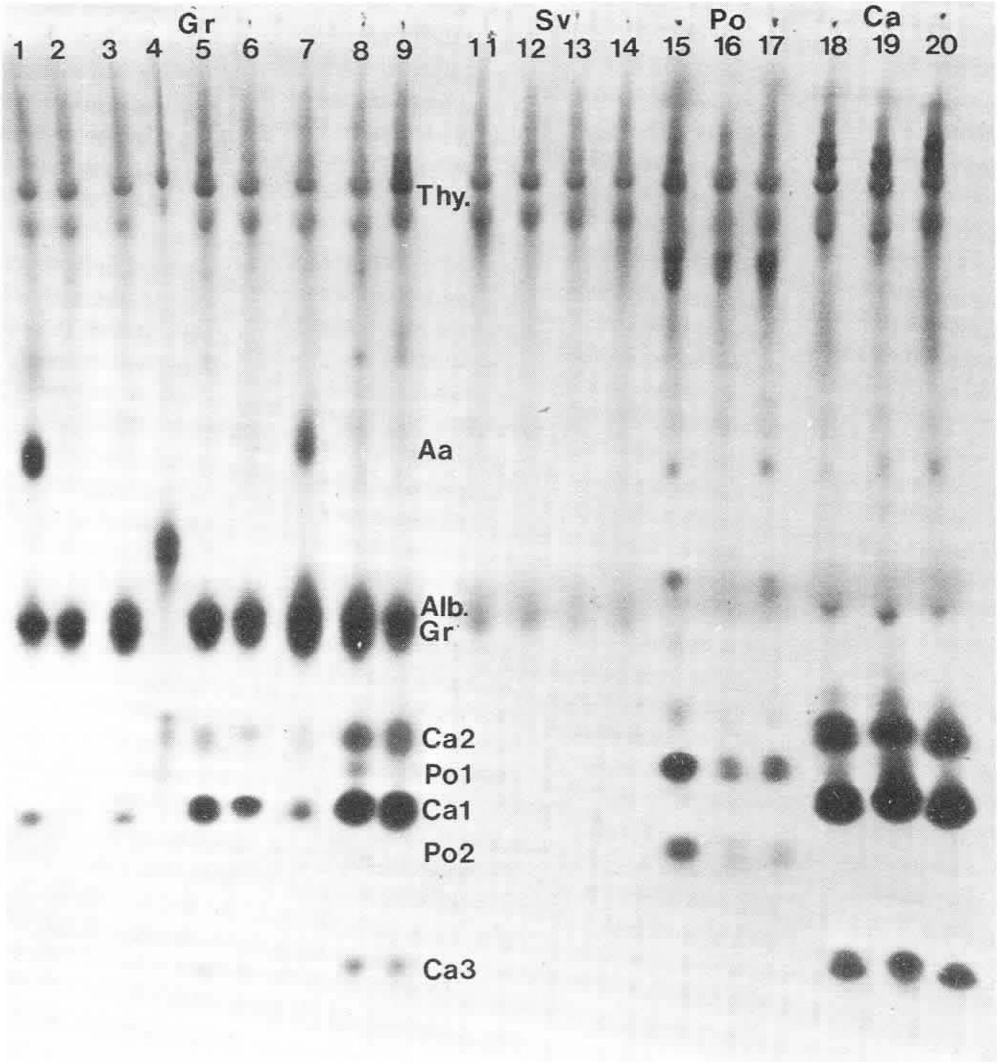

Fig. 1 – A representative gel. (Tracks run from top to bottom of the gel.) Abbreviations are: Alb, albumin marker; Thy, thyroglobulin marker; Aa, *Alaskozetes antarcticus*; Ca, *Cryptopygus antarcticus*; Gr, *Gamasellus racovitzai*; Po, *Parisotoma octooculata*; Sv, *Stereotydeus villosus*. Track numbers show Gr with traces of Aa and Ca (1,7), no prey (2), Ca only (3,5,6,9) and Ca and Po (8). Reference tracks show Sv (11–14) equivalent to marker proteins alone due to lack of specific esterase bands, Po (15–17), Ca (18–20). Track 4 is invalid (note incomplete marker band pattern).

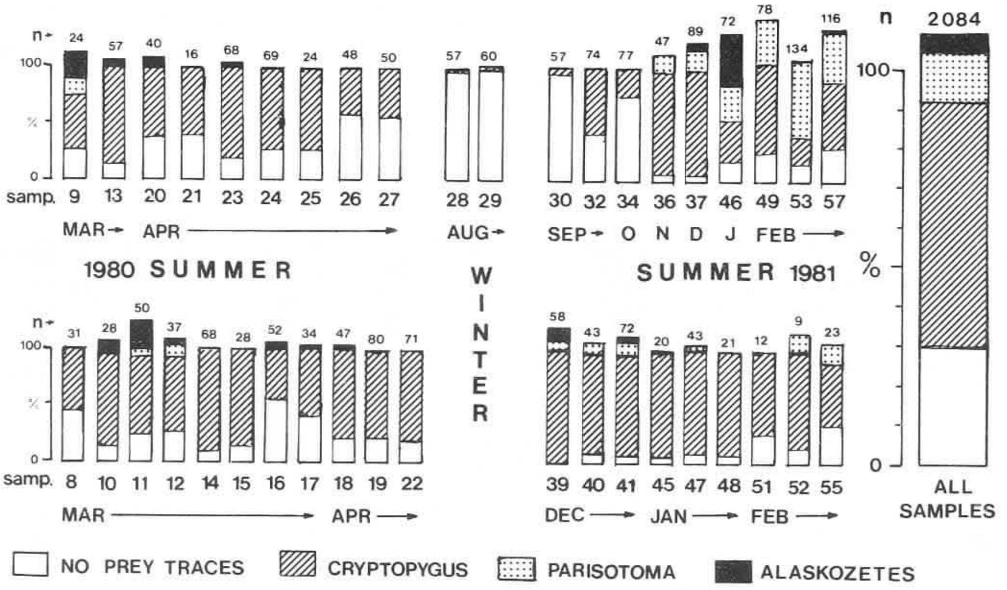

Fig. 2 – Summary of electrophoresis samples. Upper row, high nutrient sites; lower row, low nutrient sites. Samples are in chronological order within each group. Numbers of *G. racovitzai* without identifiable food traces and with traces of each prey species are expressed as percentages of the sample size, *n*. Sample sizes are given above each bar diagram, sample numbers below. A comparable diagram based on all samples is included. Generic names only have been used in the key.

Ignoring differences between sites, there is a clear seasonal trend in the proportion of the predator population with detectable food traces. During the summer months (November to March or mid-April) the 'non-feeding' proportion fluctuates around 18 per cent of the sample. As winter approaches and longer periods of sub-zero temperatures are experienced this proportion increases (samples 25–27, Fig. 2), until by mid-winter there are virtually no animals in the population with detectable food traces (samples 28, 29). Sample 30, taken three days after the first major spring thaw, shows that a normal summer feeding pattern is not reestablished immediately, despite the presence of active predators and prey in the field. By early November the pattern is normal (sample 36).

In some instances prey population densities were estimated in parallel with electrophoresis samples. Fig. 3 compares field prey ratios with those detected in *G. racovitzai*. No attempt is made to allow for possible differences in the rate at which esterases from different prey species are digested and become undetectable or for different detection thresholds, and *G. racovitzai* without any detectable traces are excluded from these comparisons, which are therefore only concerned with 'apparent diet'. Absolute prey population densities are not taken into account.

It is clear that *A. antarcticus* is under-represented in the apparent diet of *G. racovitzai* (samples 20, 53, Fig. 3). This supports Goddard's (1982) observation that the heavy sclerotization of *A. antarcticus* protects it from stylet penetration by *G. racovitzai*, which is a necessary part of the latter's feeding process. *C. antarcticus* and *P. octooculata* traces occur in the predator with approximately the same frequency as the species are present in the field. However, there is an indication of a trend towards the end of the summer to an over-representation of *P. octo-oculata* in the apparent diet of *G. racovitzai* (samples 53, 55, 57).

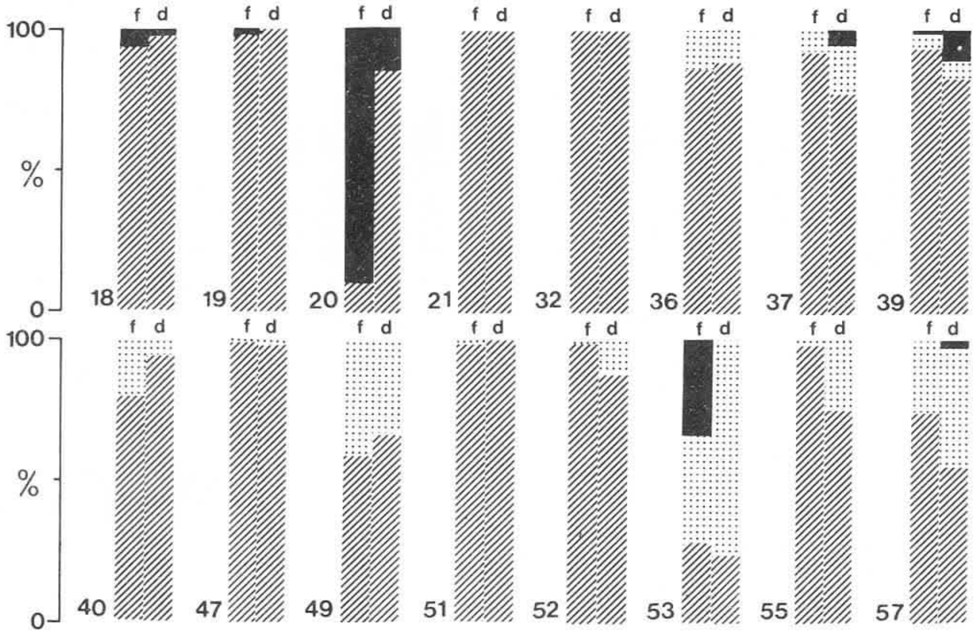

Fig. 3 – Comparison of field prey ratios with apparent diet in *G. racovitzai*. Percentage composition of prey populations estimated by soil core extraction (f) is compared with percentage composition of all detected prey traces (d) for a number of samples. Sample numbers are to the left of each bar diagram. Key to species as for Fig. 2.

There is a large degree of variation in the detectable quantity of a particular prey enzyme band between individual predators (e.g. band Ca1, Fig. 1). It was felt that a greater use could be made of the technique if the traces were quantified and related to meal size or feeding frequency. Fig. 4 shows results of an experiment designed to estimate the detection time of *C. antarcticus* traces in *G. racovitzai*. Deutonymph *G. racovitzai* were starved for an initial period of three weeks before being allowed to feed upon *C. antarcticus* for 12 h. Uneaten prey were removed and the predators starved at 5°C. The measured quantity of the Ca1 band (in arbitrary units) is plotted against time since prey removal. As a first approximation an exponential decay curve has been fitted to the data. It is anticipated that a more sophisticated regression analysis incorporating data from other bands will allow order of magnitude estimates of predation rates or energy flow through the predator population to be made.

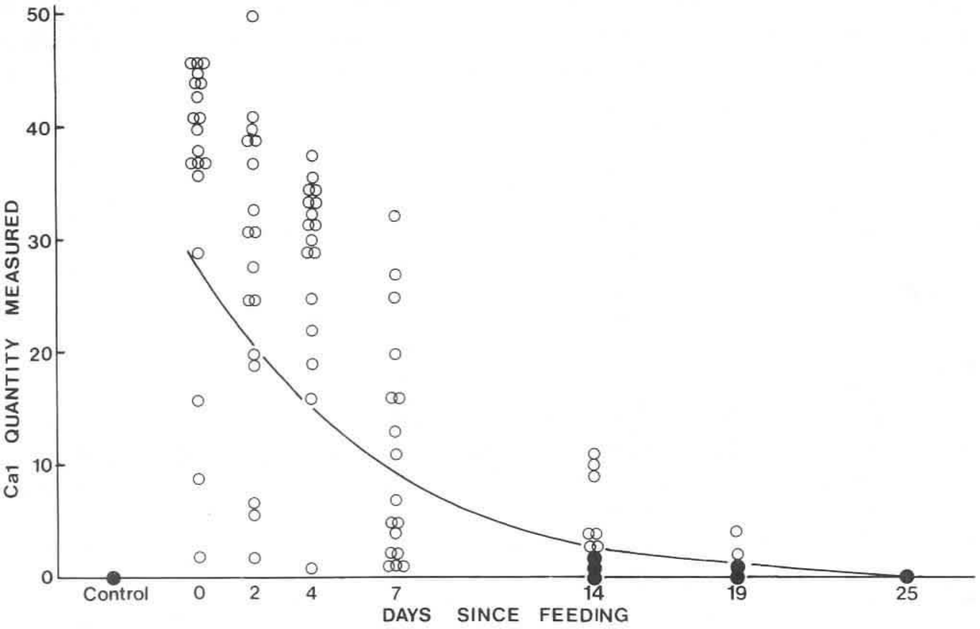

Fig. 4 – Detection time curve of *Cryptopygus antarcticus* in the predator. The measured quantity (in arbitrary units) of Ca1 band esterase in *G. racovitzai* is plotted against time since feeding. Open circles represent individual specimens, closed circles indicate four or more at one point. The regression curve: Ca1 = 27.3 exp (–0.14 days), fitted by least squares analysis, is shown.

DISCUSSION

There are two alternative explanations for the reduced proportion of predators with detectable prey traces during the winter. Block and Sømme (1982) have discussed the effect of food-derived nucleating agents in the guts of micro-arthropods from Signy Island on their ability to supercool. Micro-arthropods may exhibit a positive behavioural adaptation by voiding their guts in response to low temperature stress, but neither cold temperature acclimation nor forced starvation for periods up to 13 days at 5°C produced very marked lowering of supercooling points in *G. racovitzai* (Block & Sømme 1982). Positive behavioural adaptation in the form of voiding the gut therefore seems unlikely in *G. racovitzai*. Alternatively, digestion may continue after opportunities for prey capture have ceased, until all identifiable prey enzymes have been broken down. Walking activity, and presumably predation, ceases at –7.5°C (the chill–coma temperature, Block & Sømme 1982), and field temperatures had certainly fallen below this value by the time sample 27 (Fig. 2) was obtained.

There is no clear indication from the apparent diet that *G. racovitzai* selects its prey species in a non-proportional or 'active' fashion. Prey species are taken in proportion to their availabilities in the field. Availability of any species is a measure of its abundance and its susceptibility to capture and consumption by the predator. *A. antarcticus* is under-represented in the apparent diet possibly because the predator cannot successfully feed upon it in the field.

Two other factors may be important. The low mobility of *A. antarcticus* may lessen its risk of attack by *G. racovitzai*. *A. antarcticus* traces may persist in the gut of *G. racovitzai* for a rather shorter period than those of *C. antarcticus* or *P. octooculata*, in which case the apparent under-sampling may not actually exist.

Similar points regarding mobility and rate of digestion by the predator must be borne in mind when attempting to interpret the evidence for active selection by the predator between the two species of Collembola towards the end of summer (Fig. 3). Size is an additional factor that has not been considered. In this analysis life stages of predator and prey have not been distinguished, but changes in relative sizes of predator and prey may alter the underlying passive sampling pattern.

SUMMARY

(1) Polyacrylamide gradient gel electrophoresis was used to study the diet of the predatory mite *Gamasellus racovitzai* at Signy Island, maritime Antarctic, over a twelve-month period.

(2) More than 2000 individual predators were analysed, and traces of three principal prey species were identified.

(3) There is a strong seasonal pattern in feeding behaviour with little or no evidence of feeding during the winter (April to September).

(4) There is no conclusive evidence for active selection between alternative prey species in the field, although possible effects of life-stages of both predator and prey have been ignored.

(5) Steps toward quantifying the technique of electrophoresis have been taken. A detection time curve for *Cryptopygus antarcticus* is given, which shows identifiable traces in the gut of *G. racovitzai* for up to 19 days at 5°C.

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